Geophytology 42(2): 93-114
February 2013

Pollen analysis in understanding the foraging behaviour of *Apis mellifera* in Gangetic West Bengal

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ABSTRACT

Pal P. K. & Karmakar P. 2013. Pollen analysis in understanding the foraging behaviour of *Apis mellifera* in Gangetic West Bengal. Geophytology 42(2): 93-114.

Forage patterns, with respect to pollen as well as nectar, of *Apis mellifera* in Gangetic West Bengal throughout the year have been worked out in detail. The results are based on the pollen analysis of 1443 pollen pellets and 61 honey samples collected systematically in different months throughout the calendar year. The work reveals that the forage spectrum of *A. mellifera* in the region is constituted by altogether 77 species of flowering plants. Among those, *Cocos nucifera*, *Phoenix sylvestris*, *Borassus flabellifer*, *Citrus maxima*, *Carica papaya*, *Pongamia pinnata*, *Luffa acutangula*, *Croton bonplandianum*, *Terminalia arjuna*, *Bauhinia malabarica*, *Averrhoa carambola*, *Chrozophora rottleri*, *Monochoria hastata*, *Anthocephalus cadamba*, *Acacia auriculiformis*, *Murraya paniculata*, *Cleome viscosa*, *Eucalyptus globulus* and *Xanthium strumarium* serve as the predominant pollen source. *Brassica nigra*, *Moringa oleifera*, *Borassus flabellifer*, *Syzygium cumini*, *Sesamum indicum*, *Anthocephalus cadamba*, *Impatiens balsamina*, *Eucalyptus globulus*, *Acacia auriculiformis* and *Mikania scandens* constitute the important nectar source. For the major part of the year, *A. mellifera* produces multifloral honeys, except in September when it yields *Eucalyptus* type unifloral ones.

Key- words: Melissopalynology, nectar forage, pollen forage, unifloral honey, multifloral honey, *Apis mellifera*, Gangetic West Bengal, India

INTRODUCTION

Honey, the splendid sweet substance obtained from honeycomb, is primarily a viscous supersaturated solution of sugars. In addition, honey also contains minor amounts of insoluble carbohydrates called 'honey dextrins' (analogous to starch), enzymes, amino acids, organic acids, vitamins, minerals and water. From ancient time, use of honey for various purposes, viz. as food, medicine and in rituals, is a traditional practice. The importance of honey has been mentioned in the ancient Indian Vedas. Wide variation in constituents of different samples of honey has been noticed. It is largely influenced by the plant source together with the environmental factors like weather, soil, etc. Besides honey, other commercially important products obtained from bees are royal jelly, propolis and bee venom. Also, during the course of their foraging activities, bees act as pollinators and help in increasing the yield of many economically important plants (Free 1993). In view of the environmental onslaught on insect pollinators, beekeeping is nowadays used as an effective means to overcome the pollination crisis of bee-pollinated crops (Goyal 1993, Kumar et al. 1998).

Honeybees forage on flowering plants for collecting pollen grains and nectar for making beebread. The plants that yield these two substances collectively constitute the bee pasturage. Vegetation in the area is therefore of immense importance for establishment, maintenance and yield, i.e. all round development, of a bee colony. The forage pattern of bees varies from species to species, sometimes among varieties. In a colony, there exists a distinctive division of labour among the worker-bees

with respect to the collection of nectar and pollen grains and also for other purposes. Distinction between the nectar and pollen-collecting bees was recognized as early as in 1623 (Butler 1954). Pollen grains from anthers of flowers are carried by the designated worker bees in the form of pellets packed onto the concavities of their hind limbs referred to as the 'corbiculae' or 'pollen baskets' and are stored in the pollen-cells of the hive. Nectar from flowers is collected by a bee into its honey stomach by repeated sucking through the proboscis. The bee regurgitates the nectar in the form of a suspended drop onto the upper wall of an empty honey-cell in the comb which, in course of time, is turned into honey by the complex work of other worker bees. While collecting nectar, various parts of a bee's body incidentally get smeared with the pollen grains of flowers they visit. Eventually, honey contains pollen grains as contaminants with the collected nectar of the plants visited by bees.

Pollen analyses of honey and pollen pellets are considered to be the most suitable and widely used means to understand the forage pattern of a bee species. To decipher the details of pollen forage as well as nectar forage in an area by any particular bee species/variety, pollen analyses of both pollen pellets and honey samples are to be done simultaneously.

Melissopalynological research can be traced back to the end of the nineteenth century, when Pfister (1895) examined the pollen contents of various honey samples from different parts of Europe. In India, pollen analysis of honey was initiated by Sen and Banerjee (1956) while working on the samples collected from a small private garden of Kolkata. Subsequently, a number of workers made significant contributions in this field of knowledge. Mention may be made of Deodikar and Thakar (1953), Vishnu-Mittre (1957), Chaubal and Deodikar (1963, 1965), Nair (1964), Deodikar (1965), Sharma and Nair (1965), Sharma (1970), Chaturvedi (1973, 1977, 1983), Chaudhari (1977, 1978), Seethalakshmi and Percy (1979), Seethalakshmi (1980), Chaubal (1980), Mondal and Mitra (1980), Chanda and Ganguly (1981), Bhattacharya et al. (1983), Chakrabarti (1987), Jhansi and Ramanujam (1987, 1990), Kalpana et al. (1990), Ramanujam (1994), Ramanujam and Kalpana (1995), Kalpana and Ramanujam (1995, 1998), Malakar et al. (1995), Bera et al. (1997), Lakshmi and Suryanarayana (1997), Jana and Bera (2004), Ramakrishna and Bushan (2004), Chaya and Verma (2004) and Chauhan and Murthy (2010). However, all of the previous works were based on isolated samples and the forage pattern of any of the bee species in an area throughout the year has not yet been done.

Nine species of honeybees, viz. *Apis mellifera* L., *A. florea* Fabricus, *A. cerana* Fabricus, *A. andreniformis* Smith, *A. dorsata* Fabricus, *A. nigrocincta* Smith, *A. laboriosa* Smith, *A. koschevnikovi* Enderlein and *A. nuluensis* Tingek et al., are known to occur globally (Oldroyd & Wongsiri 2006). Among those, *A. mellifera* and *A. cerana* have been hived successfully for commercial purposes (Gotaria et al. 1998). Modern beekeeping is a recent development in India, which started with the hiving of indigenous *Apis cerana* for honey production as a hobby (Holmes 1965). Until 1960, beekeeping in the country remained confined only to this particular species. However, domestication of *Apis cerana* was found to be less fruitful because of low productivity of honey and its susceptibility to the 'Thai sac brood' disease. To solve the problem the European bee species, *Apis mellifera*, was introduced in India during mid 1960s (Goyal & Gupta 1994). The species has been preferred by Indian beekeepers and farmers because of its better yield, resistance to various diseases and easy domestication (Phadke & Wakhle 1996). Apiculture is rapidly becoming popular nowadays in West Bengal and the high yielding introduced European honeybee, *Apis mellifera*, is almost exclusively employed for the purpose. Gangetic West Bengal is characterized by a tropical monsoon climatic set-up that supports a diversified flora. About 1500 species of flowering plants are known to grow in the region. Agriculture is the prime economy of the area and it is famous for a high crop yield. The present work was undertaken to work out the month-wise nectar and pollen forage calendar of the aforesaid introduced bee species in Gangetic West Bengal. Honey samples and pollen pellets collected systematically from different parts of the region were

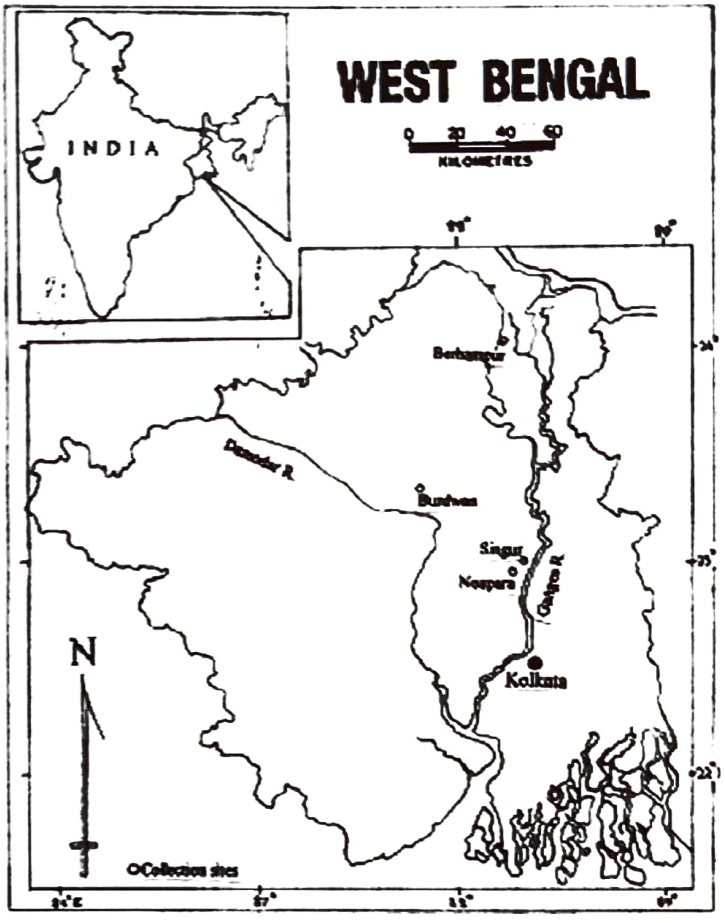
palynologically analyzed. Both qualitative and quantitative analyses were undertaken. Qualitative analysis was done to work out the plant species in the region foraged by *A. mellifera*, either for pollen or nectar or both. Quantitative analysis reveals the relative importance of the taxa in forage. A thorough survey of previously published works reveals that this sort of comprehensive approach is being made for the first time in the country.

MATERIAL AND METHOD

The present work is based on the month-wise collection of pollen pellets and honey samples of *Apis mellifera* in Gangetic West Bengal. Altogether, 1443 samples of pollen-pellets and 61 samples of honey have been collected from four localities in the region, viz. Burdwan, Noapara, Singur and Berhampur (Text-figure 1). For the purpose, six beehives of *Apis mellifera* have been maintained for more than two years (2002-2004) at Golapbag, Krishnapur and Tejgunj localities of Burdwan. Samples from other three localities were collected from the hives maintained by the professional apiculturists.

Majority of the pollen pellets were collected directly from the pollen baskets of the bees. Some pollen pellets were also recovered from the brood frames where pollen grains are stored in the pollen-cells. While doing so, pollen pellets were removed carefully with a fine needle from the pollen-cells of the hive where the pellets remain stacked one above the other. Pellets were preserved individually in small (5 ml) glass vials containing FAA (Formalin-Aceto-Alcohol, 5:5:90) solution.

In productive seasons (late January to early May and mid September to early November), sufficient amounts of honey samples were obtained when pure honey is extracted for marketing from the honey combs using honey extractor. However, in nonproductive seasons, i.e. during mid May to early September and mid November to mid January, pure honey samples of limited amount (4-5 ml) were collected directly from a few honey cells with the help of a clean and sterilized fine-tipped glass pipette aided with rubber teats.



Text-figure 1. Map of West Bengal showing the sampling sites.

Palynological slides from pollen pellets were prepared by acetolysis method (Erdtman 1960). Palynological preparations of honey samples were made by dissolving 2 ml of honey in adequate amount of distilled water followed by centrifugation and acetolysis. The methodology recommended by Maurizio (1951) and International Commission for Bee Botany (Louveaux et al. 1978) was employed for pollen analysis. Pollen grains thus prepared from the samples of pollen pellets as well as honey were examined under a Leica DMLB (Germany) bright field trinocular light microscope with 40x and 100x (oil) apochromatic objectives. Different pollen morphotypes were described using standard terminologies (Erdtman 1952, Kremp 1965, Faegri & Iversen 1989) followed by their identification with the help of reference slides prepared from the local flora as well as published accounts. Photomicrographs of suitable magnifications were made with Leica MPS-60 Photoautomat, using Kodak Gold 100, 35 mm colour films and Kodak colour printing papers.

Majority of the pellets yield pollen grains belonging to a single species. However, some samples were found to be represented by more than one species. Pollen pellets were categorized on the basis of their pollen constituents. Month-wise incidence of different categories of pellets was evaluated. Frequencies of taxa were determined on the basis of at least 100 load samples. For a mixed load, fractional values were considered on the basis of the frequencies of the taxa occurring in the load.

Quantitative analysis, for determining the frequencies of taxa in honey samples collected in a month, was based on the count of at least 100 pollen grains per sample.

OBSERVATION

Monthwise qualitative and quantitative analyses of pollen occurrence in pollen pellets

During January, 120 pellets were collected. All were found to be unifloral. Pollen grains of *Cocos nucifera, Tridax procumbens, Phoenix sylvestris, Luffa acutangula* and *Brassica nigra* were recovered from the pellets. Out of 120 load samples, 51 were comprised of pollen grains belonging to *Cocos nucifera* (42.5%), 27 of *Tridax procumbens* (22.5%), 18 of *Phoenix sylvestris* (15%) and 12 each of *Brassica nigra* (10%) and *Luffa acutangula* (10%) (Text-figure 2A).

Out of 105 load samples collected in the month of February, 96 were unifloral and remaining nine were of mixed type. Among the unifloral pellets, 39 were of *Cocos nucifera*, 21 of *Phoenix sylvestris*, twelve of *Aegle marmelos*, nine each of *Tridax procumbens* and *Solanum melongena* and six of *Litchi chinensis*. Out of the nine mixed pellets, three were of *Phoenix sylvestris* and *Cocos nucifera*, another three were of *Phoenix sylvestris* together with *Litchi chinensis* and the remaining three were of *Phoenix sylvestris* and *Bauhinia malabarica*. Considering the number of unifloral pellets together with the proportionate values in mixed ones, 38% was of *Cocos nucifera*, 25.14% of *Phoenix sylvestris*, 11.43% of *Aegle marmelos*, 8.57% each of *Tridax procumbens* and *Solanum melongena*, 6.86% of *Litchi chinensis* and 1.43% of *Bauhinia malabarica* (Text-figure 2B).

During March, 132 pellets were collected. Out of those, 120 were unifloral and remaining twelve were of mixed type. Among the unifloral pellets, 24 were of *Borassus flabellifer,* 20 were of *Citrus maxima*, twelve each of *Carica papaya, Gmelina arborea, Syzygium cumini*, eight each of *Aegle marmelos*, *Phyllanthus emblica*, *Spondias mangifera* and *Terminalia arjuna* and four each of *Polyalthia longifolia* and *Cocos nucifera*. The mixed pellets were of three types. Five were constituted of *Aegle marmelos* and *Polyalthia longifolia*, four of *Phyllanthus emblica* and *Saraca indica* and the remaining three of *Aegle marmelos* and *Litchi chinensis*. Frequency-wise, *Borassus flabellifer* was represented by 18.18%, *Citrus maxima* by 15.15%, *Aegle marmelos* by 10%, *Carica papaya, Gmelina arborea* and *Syzygium cumini* each by 9.09%, *Phyllanthus emblica* by 7.88%, *Spondias mangifera* and *Terminalia arjuna* each by 6.06%, *Polyalthia longifolia* by 3.94%, *Cocos nucifera* by 3.03% and *Litchi chinensis* and *Saraca indica* each by 1.21% (Text-figure 2C).

During April, 108 pellets were collected. Out of those, 104 were unifloral and remaining four were of mixed type. Among the unifloral pellets, 20 were of *Terminalia arjuna,* 16 each of *Luffa acutangula* and

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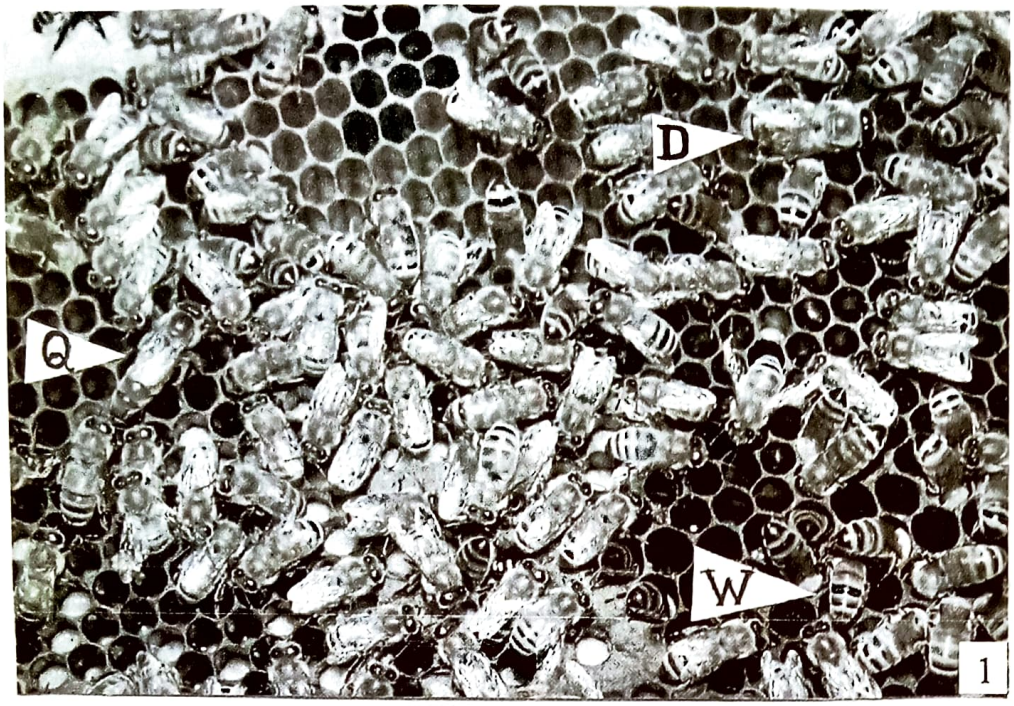
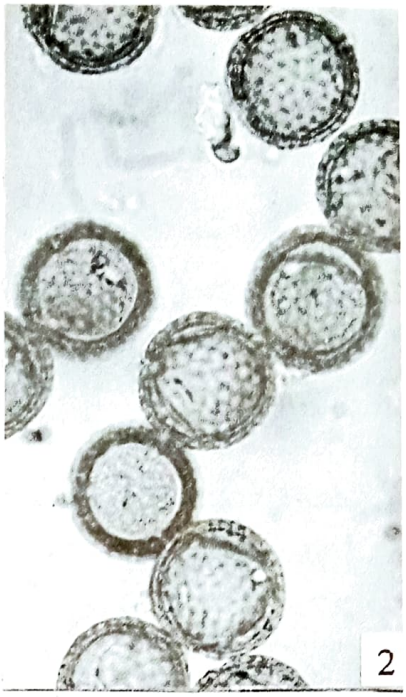
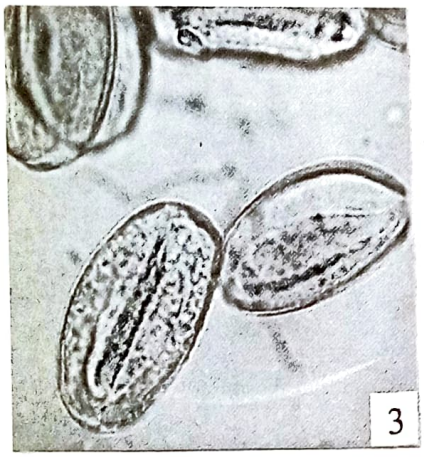
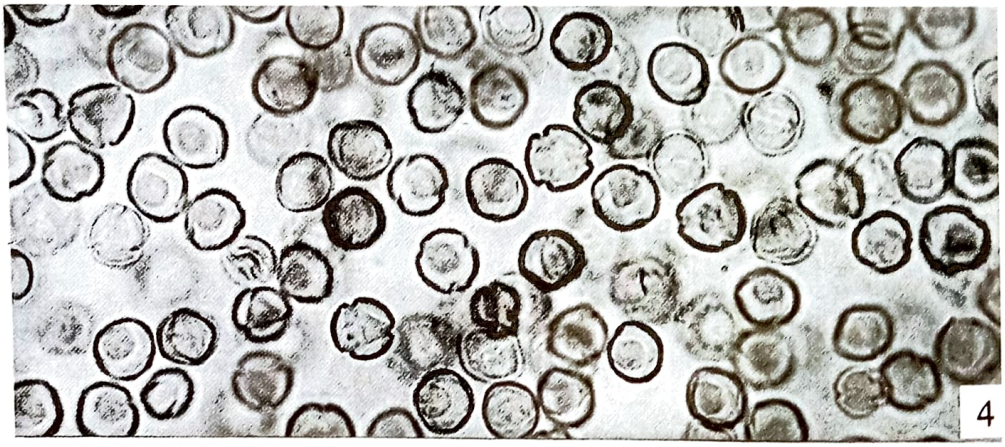
Plate 1

1. Part of a hive showing honey cells above and brood chambers below. The queen (marked as Q), drones (marked as D) and the worker bees (marked as W) are visible. 2. Acetolysed preparation of pollen load containing pollen grains of *Xanthium strumarium*, x 470. 3. Acetolysed preparation of pollen load containing pollen grains of *Monochoria hastata* showing monosulcate and rugulo-reticulate exine ornamentation, x 1175. 4. Acetolysed preparation of pollen load containing pollen grains of *Anthocephalus cadamba*, x 470. 5. Acetolysed preparation of pollen load showing 3-4 zonoparasyncolporate pollen grains of *Eucalyptus globulus* and an anasulcate pollen grain of *Cocos nucifera*, x 470. 6. Acetolysed preparation of pollen load containing pollen grains of *Cleome viscosa*, *Anthocephalus cadamba* and *Acacia auriculiformis*, x 470.









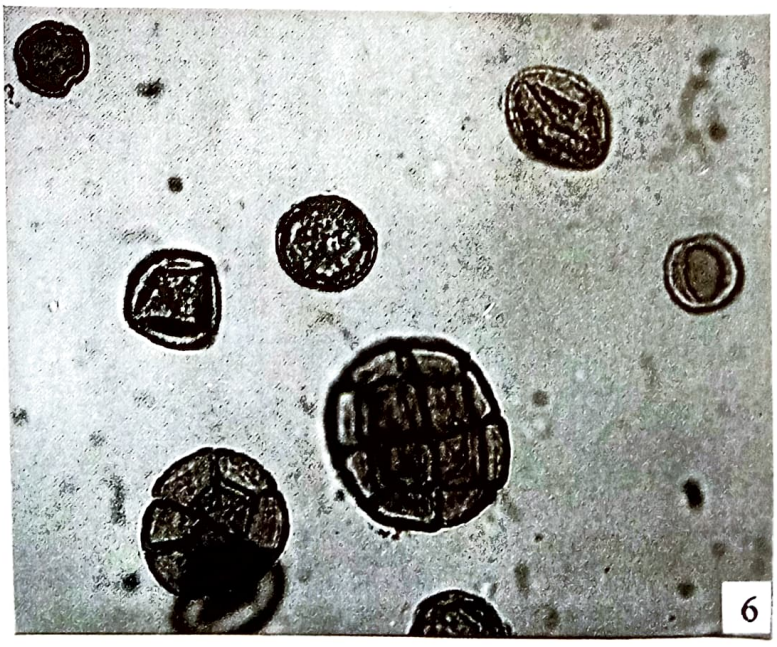


Plate 1

Pongamia pinnata, twelve each of *Borassus flabellifer, Polyalthia longifolia* and *Spondias mangifera* and eight each of *Cocos nucifera* and *Shorea robusta*. The four mixed pellets were comprised of *Croton bonplandianum* and *Jatropha gossypifolia*. Frequency-wise, *Terminalia arjuna* was represented by 18.52%, *Luffa acutangula* and *Pongamia pinnata* each by 14.81%, *Borassus flabellifer, Polyalthia longifolia* and *Spondias mangifera* each by 11.11%, *Cocos nucifera* and *Shorea robusta* each by 7.41%, *Croton bonplandianum* by 2.04% and *Jatropha gossypifolia* by 1.66% (Text-figure 2D).

During May, 114 pellets were collected. Out of those, 96 were unifloral and remaining 18 were of mixed type. Among the unifloral pellets, 31 were of *Borassus flabellifer*, 23 of *Cocos nucifera*, 15 each of *Lagerstroemia speciosa* and *Luffa acutangula* and 12 of *Citrus maxima*. The eighteen mixed pellets were of four types. Six were constituted of *Borassus flabellifer* and *Chrozophora rottleri*, other six of *Borassus flabellifer* and *Cordia sebestina*, three of *Cocos nucifera, Chrozophora rottleri, Cordia sebestina, Barringtonia acutangula* and *Syzygium jambos*, while the remaining three pellets were of *Barringtonia acutangula* and *Syzygium jambos*. Frequency-wise, *Borassus flabellifer* was represented by 31.65%, *Cocos nucifera* by 21.24%, *Lagerstroemia speciosa* and *Luffa acutangula* each by 13.16%, *Citrus maxima* by 10.53%, *Chrozophora rottleri* and *Cordia sebestina* each by 3.16%, *Barringtonia acutangula* by 2.37% and *Syzygium jambos* by 1.56% (Text-figure 2E).

During June, 120 pellets were collected. Out of those, 93 were unifloral and remaining 27 were of mixed type. Among the unifloral pellets, 27 were of *Averrhoa carambola*, 21 of *Cocos nucifera*, 15 of *Bauhinia malabarica*, nine each of *Borassus flabellifer* and *Lagerstroemia speciosa* and six each of *Dillenia indica* and *Jatropha gossypifolia*. The mixed pellets, as per their pollen constituents, were of following six types: eight containing pollen grains of *Cocos nucifera, Cordia sebestina* and *Syzygium jambos*, six of *Cocos nucifera, Chrozophora rottleri* and *Cleome viscosa*, five of *Cocos nucifera* and *Chrozophora rottleri*, four of *Bauhinia malabarica, Croton bonplandianum* and *Jatropha gossypifolia*, three of *Bauhinia malabarica* and *Chrozophora rottleri* and one of *Croton bonplandianum* and *Jatropha gossypifolia*. Frequency-wise, *Averrhoa carambola* was represented by 22.50%, *Cocos nucifera* by 21.2%, *Bauhinia malabarica* by 15.25%, *Chrozophora rottleri* by 10.25%, *Borassus flabellifer* and *Lagerstroemia speciosa* each by 7.5%, *Jatropha gossypifolia* by 7%, *Dillenia indica* by 5%, *Croton bonplandianum* by 1.75%, *Cordia sebestina* and *Syzygium cumini* each by 0.75% and *Cleome viscosa* by 0.5% (Text-figure 2F).

During July, 102 pellets were collected. Out of those, 100 were unifloral and remaining two were of mixed type. Among the unifloral pellets, 14 each were of *Anthocephalus cadamba*, *Cleome viscosa* and *Monochoria hastata*, twelve of *Acacia auriculiformis*, eleven of *Cocos nucifera*, ten of *Murraya paniculata*, eight each of *Averrhoa carambola* and *Lagerstroemia speciosa*, four each

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Plate 2

1. Equatorial view of a pollen grain of *Anthocephalus cadamba*, x 1175. 2. Polar view of a pollen grain of *Anthocephalus cadamba*, x 1175. 3. Equatorial view of a pollen grain of *Bauhinia malabarica*, x 1175. 4. Equatorial view of a pollen grain of *Phoenix sylvestris*, x 1175. 5. Equatorial view of a pollen grain of *Cocos nucifera*, x 1175. 6. Equatorial view of a pollen grain of *Limonia acidissima*, x 1175. 7. Polar view of a pollen grain of *Limonia acidissima*, x 1175. 8. Polar view of a pollen grain of *Litchi chinensis*, x 1175. 9. Equatorial view of a pollen grain of *Litchi chinensis*, x 1175. 10. Equatorial view of a pollen grain of *Poa gangetica*, x 1175. 11. Equatorial view of a pollen grain of *Phyllanthus emblica*, x 1175. 12. Polar view of a pollen grain of *Phyllanthus emblica*, x 1175. 13. Equatorial view of a pollen grain of *Polyalthia longifolia*, x 1175. 14. Polar view of a pollen grain of *Polyalthia longifolia*, x 1175. 15. Polar view of a pollen grain of *Averrhoa carambola*, x 1175. 16. Polar view of a pollen grain of *Psidium guajava*, x 1175. 17. Equatorial view of a pollen grain of *Cleome viscosa*, x 1175. 18. Polar view of a pollen grain of *Chrozophora rottleri*, x 1175. 19. Pollen grain of *Sida acuta* in optical section, x 470. 20. Pollen grain of *Sida acuta*, showing surface features, x 470. 21. Pollen grain of *Croton bonplandianum*, x 1175. 22. Polar view of a pollen grain of *Citrus maxima* showing microreticulate sculpturing, x 1175. 23. Polar view of a pollen grain of *Citrus maxima* in optical section, x 1175.

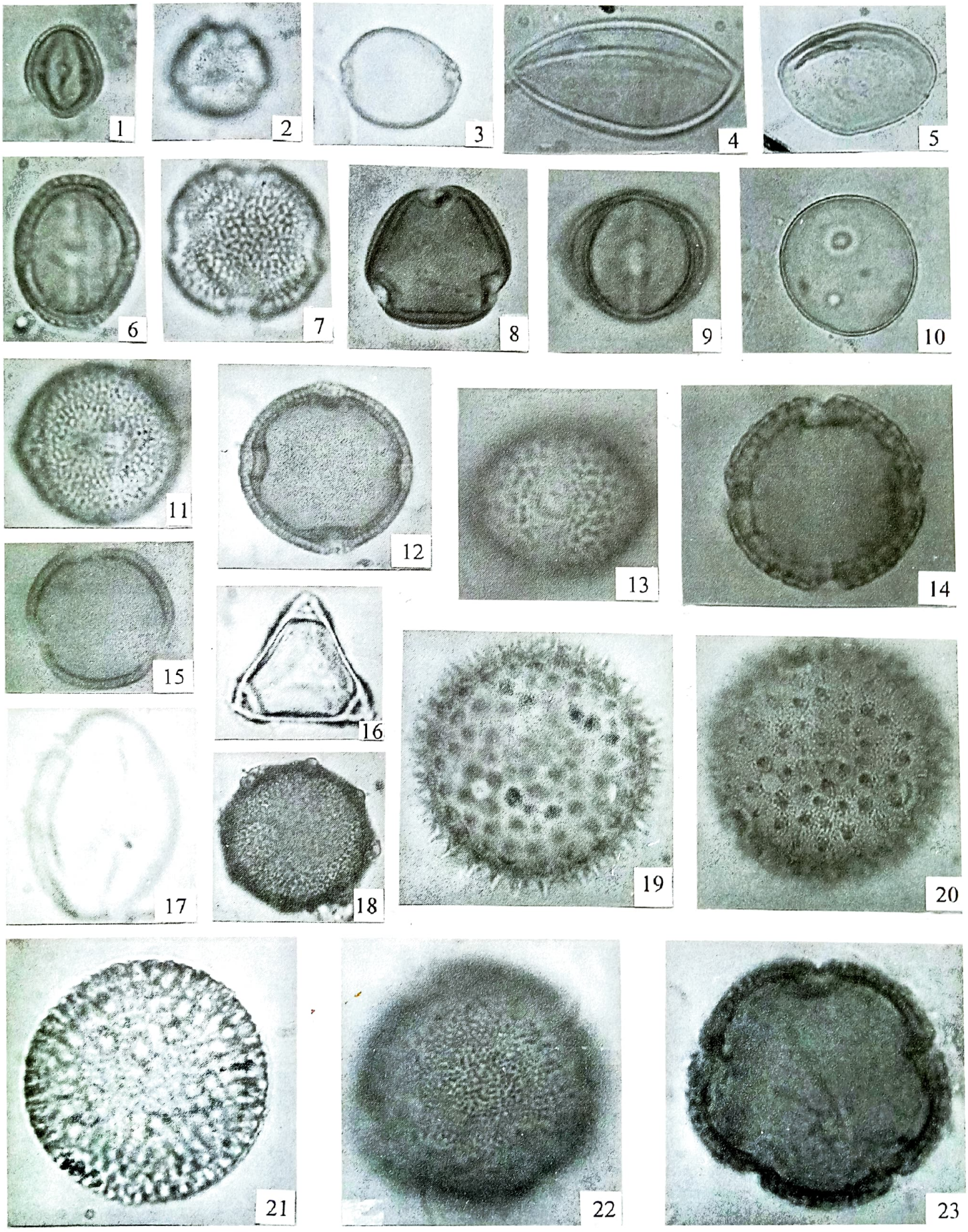
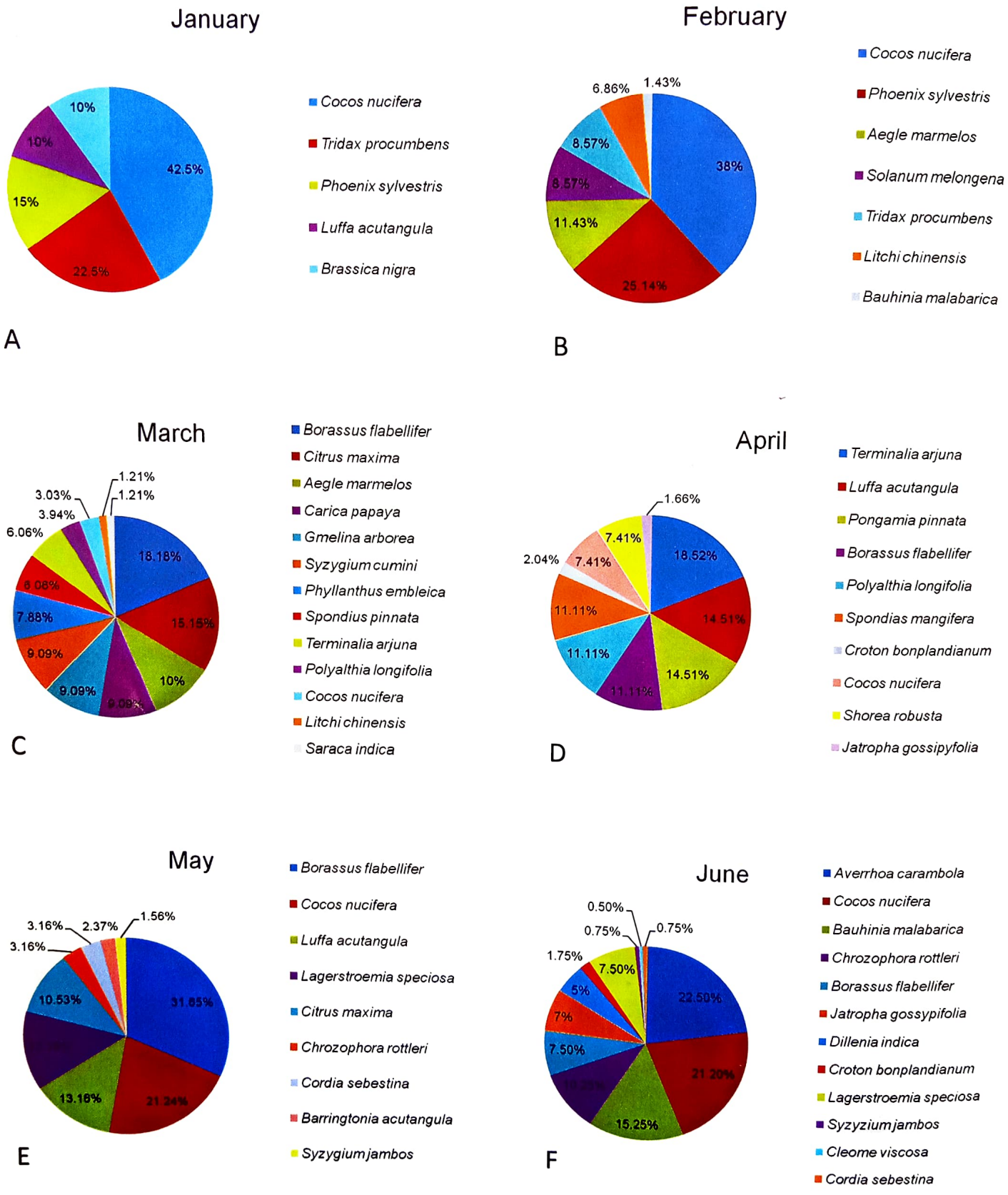


Plate 2



Text figure 2. Pie diagrammes of month-wise pollen forage by *Apis mellifera* in Gangetic West Bengal (January- June).

of *Eucalyptus globulus* and *Syzygium cumini* and one of *Bauhinia malabarica*. The mixed pellets as per their pollen constituents were of one type containing pollen grains of *Cocos nucifera* and *Bauhinia malabarica*. Frequency-wise, *Anthocephalus cadamba*, *Cleome viscosa* and *Monochoria hastata* each were represented by 13.73%, *Cocos nucifera* by 12.55%, *Acacia auriculiformis* by 11.76%, *Murraya paniculata* by 9.80%, *Averrhoa carambola* and *Lagerstroemia speciosa* by 7.84%, *Eucalyptus globulus* and *Syzygium cumini* by 3.92% and *Bauhinia malabarica* by 1.18% (Text-figure 3A).

During August, 136 pellets were collected. Out of those, 132 were unifloral and remaining four were of mixed type. Among the unifloral pellets, 68 were of *Cocos nucifera,* 16 of *Murraya paniculata,* twelve each of *Anthocephalus cadamba* and *Borassus flabellifer,* eight each of *Bauhinia malabarica* and *Cleome viscosa* and four each of *Acacia auriculiformis* and *Monochoria hastata.* The mixed pellets as per their pollen constituents were of one type containing pollen grains of *Acacia auriculiformis, Anthocephalus cadamba* and *Cleome viscosa.* Frequency-wise, *Cocos nucifera* was represented by 50%, *Murraya paniculata* by 11.76%, *Anthocephalus cadamba* by 10%, *Borassus flabellifer* by 8.82%, *Cleome viscosa* by 6.76%, *Bauhinia malabarica* by 5.88%, *Acacia auriculiformis* by 3.82% and *Monochoria hastata* by 2.94% (Text-figure 3B).

During September, 117 pellets were collected. Out of those, 114 were unifloral and remaining three were of mixed type. Among the unifloral pellets, 33 were of *Acacia auriculiformis,* 24 were of *Cocos nucifera*, 15 each of *Eucalyptus globulus* and *Martynia annua*, twelve of *Sida acuta,* six of *Poa gangetica* and three each of *Bauhinia malabarica*, *Monochoria hastata* and *Murraya paniculata*. The mixed pellets as per their pollen constituents were of one type containing pollen grains of *Eucalyptus globulus* and *Cocos nucifera*. Frequency-wise, *Acacia auriculiformis* was represented by 28.21%, *Cocos nucifera* by 22.05%, *Eucalyptus globulus* by 13.85%, *Martynia annua* by 12.82%, *Sida acuta* by 10.26%, *Poa gangetica* by 5.13% and *Bauhinia malabarica*, *Monochoria hastata* and *Murraya paniculata* each by 2.56 % (Text-figure 3C).

During October, 117 pellets were collected. Out of those, 114 were unifloral and remaining three were of mixed type. Among the unifloral pellets, 39 were of *Acacia auriculiformis,* 27 of *Xanthium strumarium*, 12 each of *Cocos nucifera* and *Murraya paniculata*, 9 each of *Monochoria hastata* and *Sida acuta* and six of *Tridax procumbens*. The mixed pellets as per their pollen constituents were of one type containing pollen grains of *Cocos nucifera* and *Monochoria hastata*. Frequency-wise, *Acacia auriculiformis* was represented by 33.33%, *Xanthium strumarium* by 23.08%, *Cocos nucifera* by 11.28%, *Murraya paniculata* by 10.26%, *Monochoria hastata* by 9.23%, *Sida acuta* by 7.69% and *Tridax procumbens* by 5.13% (Text-figure 3D).

During November, 144 pellets were collected. Out of those, 143 were unifloral and one of mixed type. Among the unifloral pellets, 31 were of *Cocos nucifera*, 21 each of *Acacia auriculiformis* and *Tridax procumbens*, 18 of *Brassica nigra*, 16 of *Monochoria hastata*, twelve each of *Luffa acutangula* and *Sida acuta*, nine of *Xanthium strumarium* and three of *Eucalyptus globulus*. The mixed pellet, as per the pollen constituent was of *Cocos nucifera* and *Monochoria hastata*. Frequency-wise, *Cocos nucifera* was represented by 22.08%, *Acacia auriculiformis* and *Tridax procumbens* each by 14.58%, *Brassica nigra* by 12.50%, *Monochoria hastata* by 11.25%, *Luffa acutangula* and *Sida acuta* each by 8.33%, *Xanthium strumarium* by 6.25% and *Eucalyptus globulus* by 2.08% (Text-figure 3E).

During December, 128 pellets were collected. All were found to be unifloral. Pollen grains of *Cocos nucifera*, *Acacia auriculiformis*, *Brassica nigra, Sida acuta, Tridax procumbens* and *Luffa acutangula* were recovered from the pellets. Out of 128 load samples, 32 each were of *Acacia auriculiformis* and *Brassica nigra* (25%), 28 of *Cocos nucifera* (21.88%), 20 of *Sida acuta* (15.63%) and eight each of *Luffa acutangula* and *Tridax procumbens* (6.25%) (Text-figure 3F).

Table 1. Pollen forage calendar of *Apis mellifera* in Gangetic West Bengal.

Incidence Month	Most frequent	Moderately frequent	Less frequent
JAN	*Cocos nucifera, Tridax procumbens*	*Phoenix sylvestris, Luffa acutangula, Brassica nigra*	–
FEB	*Cocos nucifera, Phoenix. sylvestris*	*Aegle marmelos, Tridax procumbens,Solanum melongena, Litchi chinensis*	*Bauhinia malabárica*
MAR	–	*Borassus flabellifer, Citrus maxima, Aegle marmelos, Carica papaya, Gmelina arborea, Syzygium cumini, Phyllanthus emblica, Spondias mangifera, Terminalia arjuna*	*Polyalthia longifolia, Cocos nucifera, Litchi chinensis, Saraca indica*
APR	–	*Terminalia arjuna, Luffa acutangula, Pongamia pinnata, Borassus flabellifer Polyalthia longifolia, Spondias mangifera, Cocos nucifera, Shorea robusta*	*Croton bonplandianum, Jatropha gossypifolia*
MAY	*Borassus flabellifer, Cocos nucifera*	*Lagerstroemia speciosa, Luffa acutangula, Citrus maxima*	*Chrozophora rottleri, Cordia sebestina, Barringtonia acutangula, Syzygium jambos*
JUN	*Averrhoa carambola, Cocos nucifera*	*Bauhinia malabarica, Chrozophora rottleri, Borassus flabellifer, Lagerstroemia speciosa, Jatropha gossypifolia, Dillenia indica*	*Croton bonplandianum, Syzygium cumini, Cordia sebestina, Cleome viscosa*
JUL	–	*Anthocephalus cadamba, Cleome viscosa, Monochoria hastata, Cocos nucifera, Acacia auriculiformis, Murraya paniculata, Averrhoa carambola, Lagerstroemia speciosa*	*Eucalyptus globulus, Syzygium cumini, Bauhinia malabárica*
AUG	*Cocos nucifera*	*Murraya paniculata, Anthocephalus cadamba, Borassus flabellifer, Bauhinia malabarica,Cleome viscosa*	*Acacia auriculiformis, Monochoria hastata*
SEP	*Acacia auriculiformis, Cocos nucifera*	*Eucalyptus globulus, Martynia annua, Sida acuta, Poa gangetica*	*Bauhinia malabarica, Monochoria hastata, Murraya paniculata*
OCT	*Acacia auriculiformis, Xanthium strumarium*	*Cocos nucifera, Murraya paniculata, Monochoria hastata, Sida acuta, Tridax procumbens*	–
NOV	*Cocos nucifera*	*Acacia auriculiformis, Tridax procumbens, Brassica nigra, Monochoria hastata, Luffa acutangula, Sida acuta, Xanthium strumarium*	*Eucalyptus globulus*
DEC	*Acacia auriculiformis, Brassica nigra, Cocos nucifera*	*Sida acuta, Luffa acutangula, Tridax procumbens*	–

→

Plate 3

1. Equatorial view of a pollen grain of *Terminalia arjuna*, x 1175. 2. Polar view of a pollen grain of *Pongamia pinnata*, x 1175. 3. Polar view of a pollen grain of *Mangifera indica*, x 1175. 4. Polar view of a pollen grain of *Brassica nigra*, x 1175. 5. Polar view of a pollen grain of *Psidium guajava*, x 1175. 6. Pollen grain of *Spinacea oleracea*, x 1175. 7. Polar view of a pollen grain of *Tamarindus indica*, x 1175. 8. Pollen grain of *Alangium salvifolium*, x 1175. 9. Polar view of a pollen grain of *Dillenia indica*, x 1175. 10. Polar view of a pollen grain of *Coccinia grandis*, x 1175. 11. Polar view of a pollen grain of *Buchanania indica*, x 1175. 12. Polar view of a pollen grain of *Melia azedarach*, x 1175. 13. Polar view of a pollen grain of *Swietenia mahagoni*, x 1175. 14. Equatorial view of a pollen grain of *Mimusops elengi*, x 1175. 15. Polar view of a pollen grain of *Ziziphus mauritiana*, x 1175. 16. Equatorial view of a pollen grain of *Tridax procumbens*, x 1175. 17. Equatorial view of a pollen grain of *Lathyrus sativus*, x 1175. 18. Polar view of a pollen grain of *Moringa oleifera*, x 1175. 19. Polar view of a pollen grain of *Luffa acutangula*, x 1175.

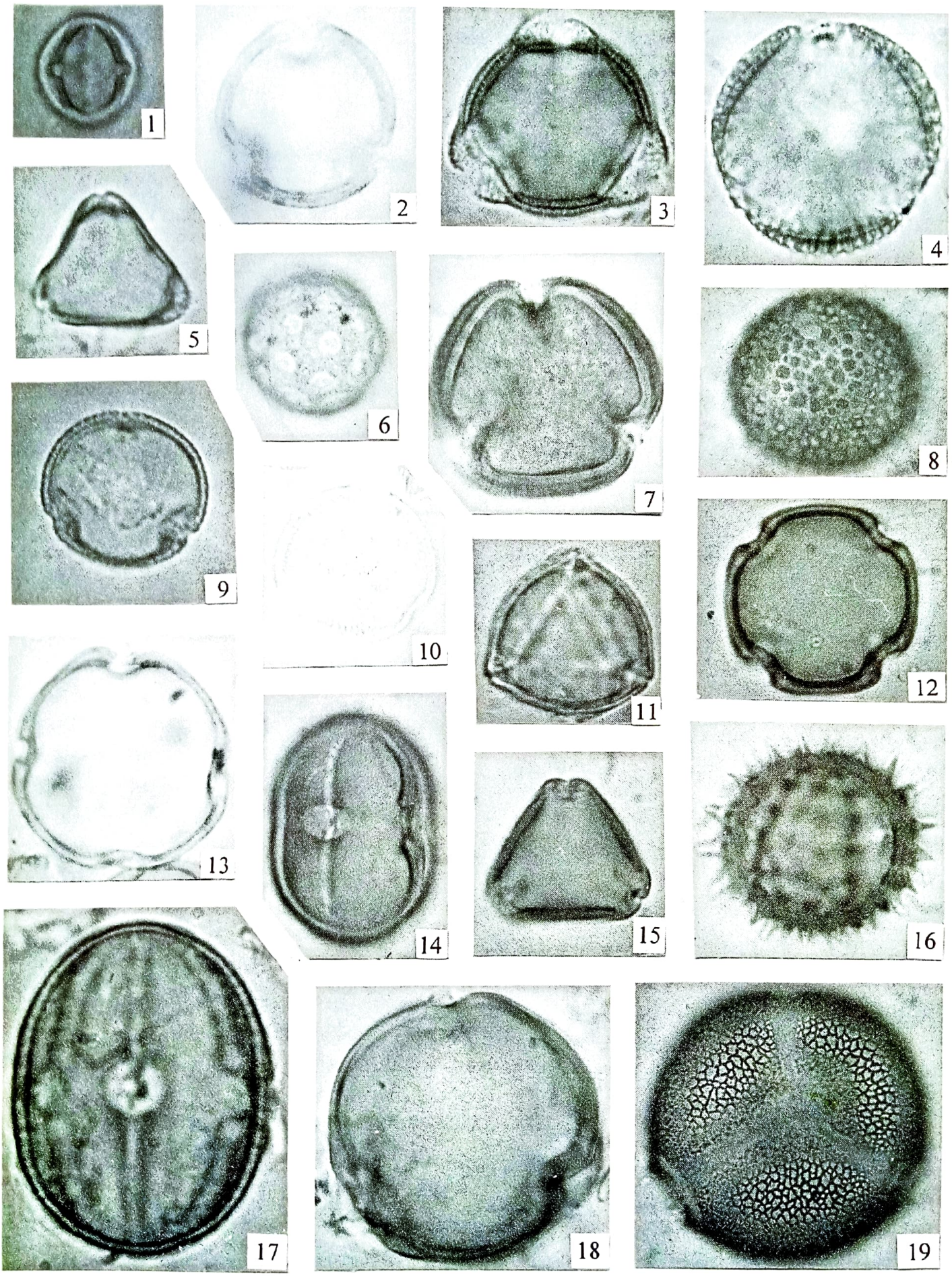
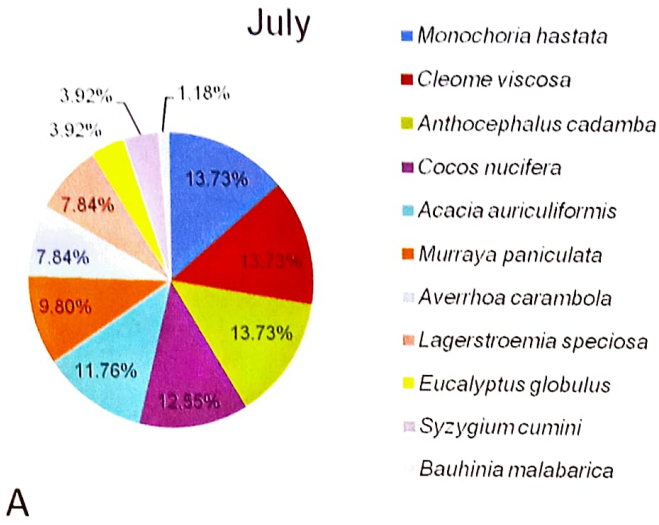


Plate 3



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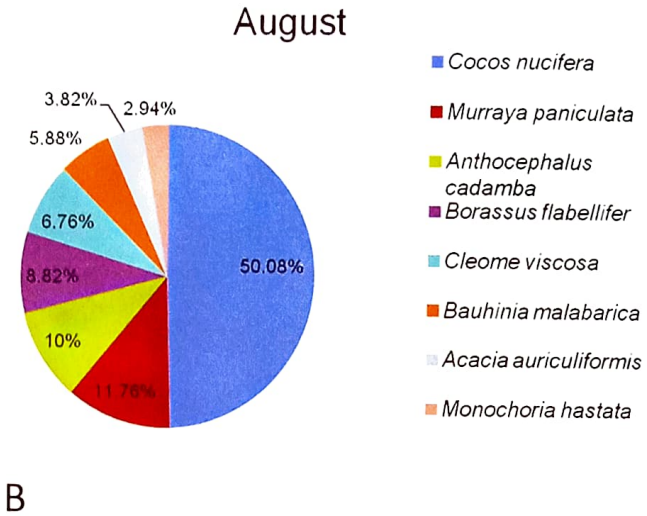

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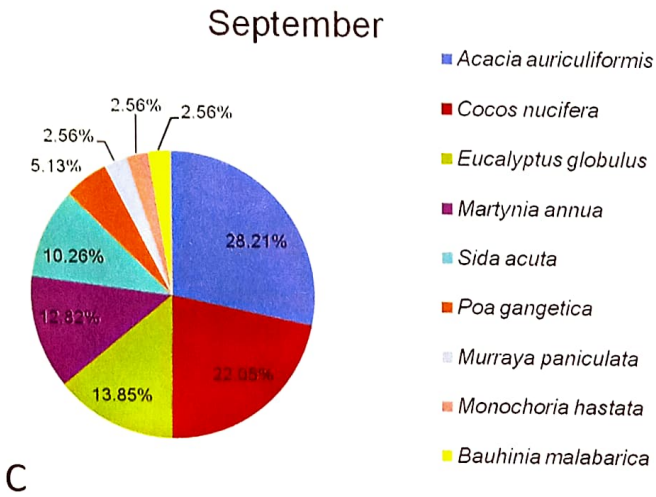

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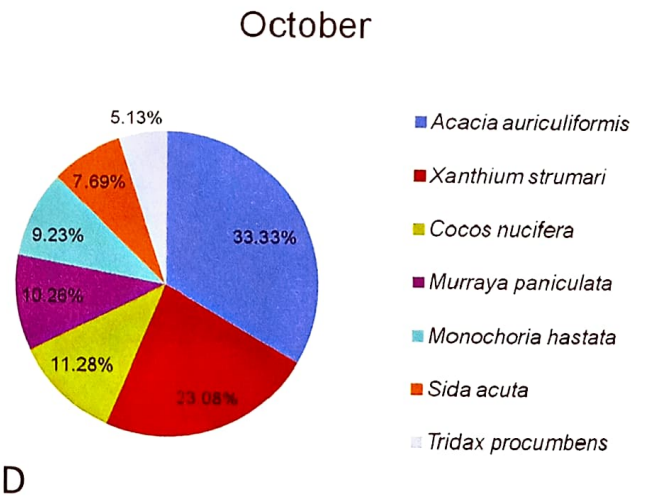

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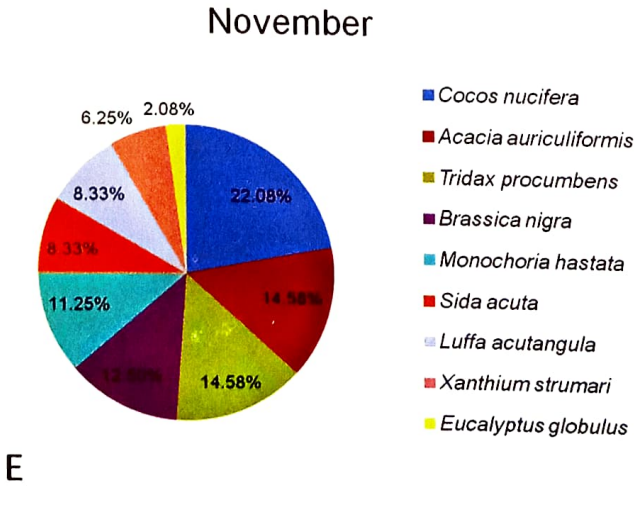

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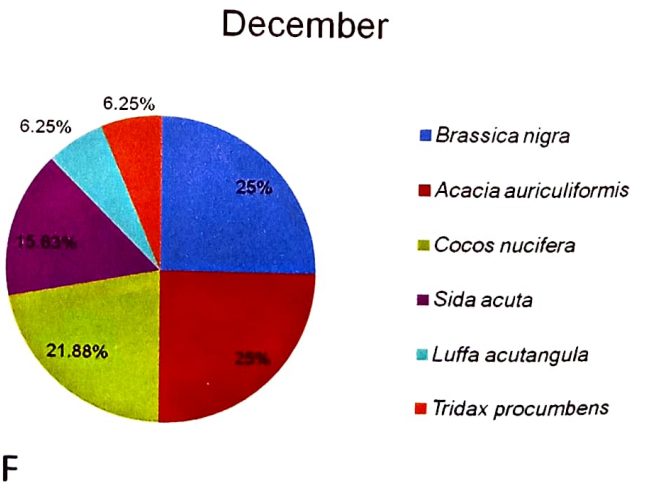

F

Text figure 3. Pie diagrammes of month-wise pollen forage by *Apis mellifera* in Gangetic West Bengal (July - December).

The month-wise pollen forage calendar of *Apis mellifera* in Gangetic West Bengal is detailed in Table 1.

Monthwise qualitative and quantitative analyses of pollen occurrence in honey samples

Honey samples were collected at regular intervals in different months of the year to understand the nectar forage pattern by the bee species. Altogether, 61 honey samples were collected from the extracted honey in productive seasons and from honey cells of the hives in nonproductive seasons.

Acetolysed preparations of the honey samples were qualitatively analysed. Pollen grains belonging to following species of flowering plants were met with.

During January, five samples of honey were collected from the honey cells. All the samples were multifloral. Quantitative analysis, based on the count of 100 pollen grains from each sample, reveals that pollen grains of *Brassica nigra* (37.5%) were the most frequent, followed by those of *Acacia auriculiformis* (20%), *Cocos nucifera* (16.5%), *Ziziphus mauritiana* (12.5%) and *Tridax procumbens* (10%) which were moderately frequent and pollen grains of *Coccinia grandis* (3.5%) were less frequent (Text-figure 4A).

In February, five samples, three from honey cells of hives and two of extracted honey, were analysed. All samples were multifloral. During this month, most frequently occurring taxa met with in honey samples were *Moringa oleifera* (35%) and *Brassica nigra* (23.5%). Pollen grains of *Cocos nucifera* (19%), *Ziziphus mauritiana* (10%) and *Mangifera indica* (10%) were moderately frequent and those of *Psidium guajava* (2.5%) were less frequent (Text-figure 4B).

During March, seven samples, three from honey cells of hives and four of extracted honey were analysed. All samples were multifloral. Pollen grains of *Borassus flabellifer* (18%), *Syzygium cumini* (14%) and *Moringa oleifera* (12%) were moderately frequent, while *Phyllanthus emblica* (7%), *Terminalia arjuna* and *Raphanus sativus* (5% each), *Aegle marmelos, Azadirachta indica, Polyalthia longifolia, Pongamia pinnata, Psidium guajava* and *Spinacea oleracea* (4% each), *Litchi chinensis, Mangifera indica* and *Tamarindus indica* (3% each), *Punica granatum* and *Anisomeles ovata* (2% each), *Hygrophila schulli* (1%) and *Lathyrus sativus* and *Peltophorum pterocarpum* (0.5% each) were less frequent (Text-figure 4C).

In April, six samples, three from honey cells of hives and three of extracted honey were analysed. All samples were multifloral. During this month, most frequently occurring taxa met with in honey samples were *Borassus flabellifer* (32%) and *Syzygium cumini* (21%). Pollen grains of *Melia azedarach* (10%), *Brassica nigra* and *Pongamia pinnata* 8% were moderately frequent and *Shorea robusta* (6%), *Aegle marmelos* (4%), *Hygrophila schulli* and *Peltophorum pterocarpum* (3%) and *Rosa chinensis* (2%) were less frequent (Text-figure 4D).

In May, five samples, three from honey cells of hives and two of extracted honey were analysed. All samples were multifloral. Quantitative analysis of the honey samples reveals that pollen grains of *Sesamum indicum* (27%) were most frequent, followed by those of *Syzygium cumini* (10%) and *Holarrhena pubescens* (9%) which were moderately frequent and *Chrozophora rottleri, Azadirachta indica* (7% each), *Aegle marmelos, Pongamia pinnata, Alangium salvifolium* (6% each), *Saraca indica, Dillenia indica* (5% each), *Adhatoda vasica* (4%), *Allamanda cathartica* and *Shorea robusta* (3% each) and *Jasminum auriculatum* (2%) were less frequent (Text-figure 4E).

In June, five samples of honey were collected from the honey cells. All the samples were multifloral. Pollen grains of *Borassus flabellifer* (17%), *Cocos nucifera, Datura fastuosa, Sesamum indicum* and *Terminalia arjuna* (15% each), *Momordica charantia* (13%) and *Spondias mangifera* (10%) were moderately frequent (Text-figure 4F).

In July, altogether four samples of honey were collected from the honey cells. All the samples were multifloral. During this month, most frequently occurring taxon met with in honey samples was *Anthocephalus cadamba* (32%). Pollen grains of *Terminalia arjuna* (14%) and *Cocos nucifera* (12%) were moderately frequent, whereas less frequent pollen grains were

Holarrhena pubescens, Syzygium cumini (8% each), *Erythrina variegata, Vitex negundo, Tectona grandis* (5% each), *Coccinia grandis, Martynia annua* (4% each) and *Allamanda cathartica* (3%) (Text-figure 5A).

In August, five samples of honey were collected from the honey cells. All the samples were multifloral. Quantitative analysis of the honey samples revealed that pollen grains of *Impatiens balsamina* (40%) were most frequent followed by those of *Cocos nucifera* (22%), *Cucurbita maxima* and *Mimusops elengi* (15% each) which were moderately frequent and those of *Adhatoda vasica* (8%) were less frequent (Text-figure 5B).

In September, six samples, three from honey cells of hives and three of extracted honey, were analysed. All the samples were unifloral. The most frequent pollen grains were of *Eucalyptus globulus* (55%), followed by the moderately frequent pollen grains of *Acacia auriculiformis* (30%) and *Nyctanthes arbortristis* (15%) (Text-figure 5C).

In October, four samples of honey were collected from the honey cells. All the samples were multifloral. Quantitative analysis of the honey samples revealed that pollen grains of *Acacia auriculiformis* (42%) were the most frequent followed by those of *Ziziphus mauritiana* (30%) and *Tridax procumbens* (20%) that were moderately frequent and those of *Rosa chinensis* (8%) were less frequent (Text-figure 5D).

In November, altogether five samples of honey were collected from the honey cells. All the samples were multifloral. During this month, most frequently occurring taxon met with in honey samples was *Eucalyptus globulus* (32%). Pollen grains of *Cocos nucifera* (20%), *Tridax procumbens* (18%), *Brassica nigra* and *Ziziphus mauritiana* (15% each) were moderately frequent (Text-figure 5E).

In December, four samples of honey were collected from the honey cells. All the samples were multifloral. Quantitative analysis of the honey samples revealed that pollen grains of *Brassica nigra* (35%) were most frequent, followed by those of *Mikania scandens* (18%), *Datura fastuosa* (11%), *Cocos nucifera* and *Ziziphus mauritiana* (10% each) which were moderately frequent and *Acacia auriculiformis* (7%), *Jasminum auriculatum* (5%), *Sesamum indicum* (3%) and *Zinnia elegans* (1%) were less frequent (Text-figure 5F).

The month-wise nectar forage calendar of *Apis mellifera* in Gangetic West Bengal is detailed in Table 2.

DISCUSSION

Present work reveals that in Gangetic West Bengal, flowers belonging to altogether 73 species of angiosperms are visited by *A. mellifera.* Majority of those have been depicted in Plates 1-4. Among those, 33 species are foraged exclusively for nectar. Those are *Adhatoda vasica, Alangium salviifolium, Allamanda cathartica, Anisomeles ovata, Azadirachta indica, Coccinia grandis, Cucurbita maxima, Datura fastuosa, Erythrina variegata, Holarrhena pubescens, Hygrophila schulli, Impatiens balsamina, Jasminum auriculatum, Lathyrus sativus, Mangifera indica, Melia azedarach, Mikania scandens, Mimusops elengi, Moringa oleifera, Momordica charantia, Nyctanthes arbor-tristis, Peltophorum pterocarpum, Psidium guajava, Punica granatum, Raphanus sativus, Rosa chinensis, Sesamum indicum, Spinacea oleracea, Terminalia arjuna,*

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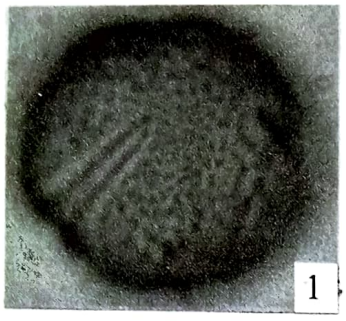
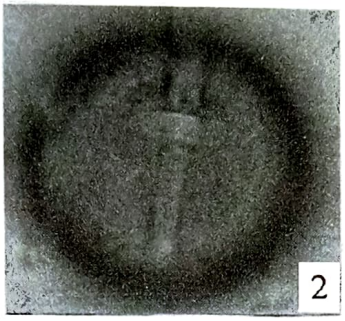
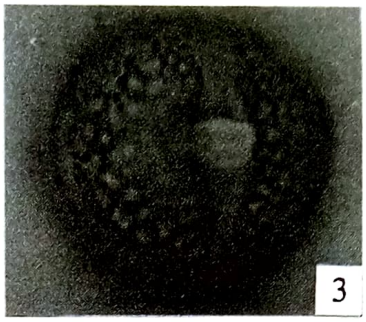
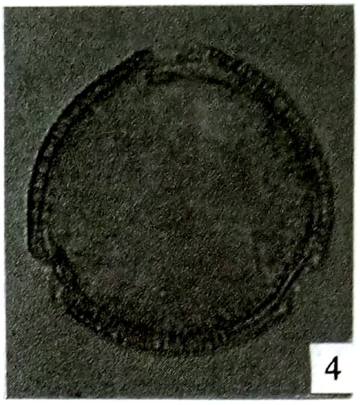
Plate 4

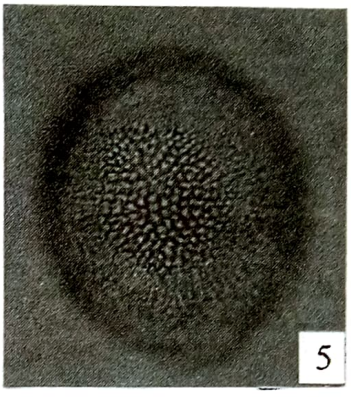
1. Polar view of a pollen grain of *Carica papaya*, x 1175. 2. Equatorial view of a pollen grain of *Carica papaya*, x 1175. 3. Equatorial view of a pollen grain of *Aegle marmelos*, x 1175. 4. Polar view of a pollen grain of *Momordica charantia*, x 1175. 5. Equatorial view of a pollen grain of *Momordica charantia*, x 1175. 6. Preparation of honey sample comprising pollen grains of *Psidium guajava, Syzygium cumini, Azadirachta indica, Aegle marmelos, Moringa oleifera* and *Peltophorum ferrugineum* under low magnification, x110. 7. Polar view of some pollen grains of *Syzygium cumini*, x 470. 8. Equatorial view of a pollen grain of *Barringtonia acutangula*, x 1175. 9. Equatorial view of a pollen grain of *Murraya paniculata*, x 1175. 10. Pollen grains of *Borassus flabellifer*, x 470. 11. Pollen grain of *Martynia annua*, x 1175. 12. Equatorial view of a pollen grain of *Erythrina variegata*, x 1175. 13. Pollen grain of *Jatropha gossypifolia*, x 1175.

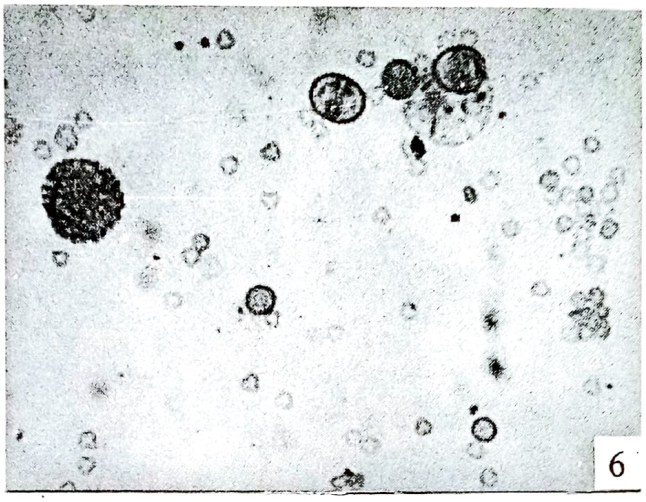


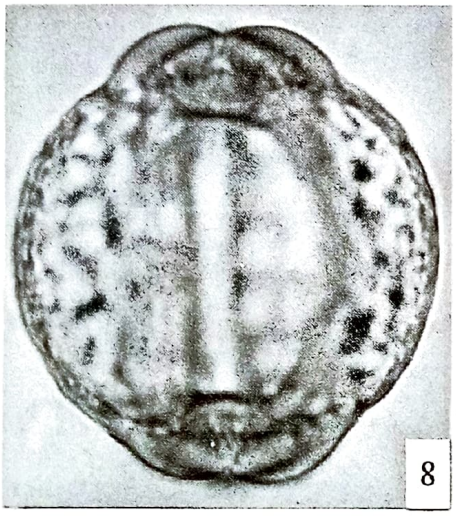


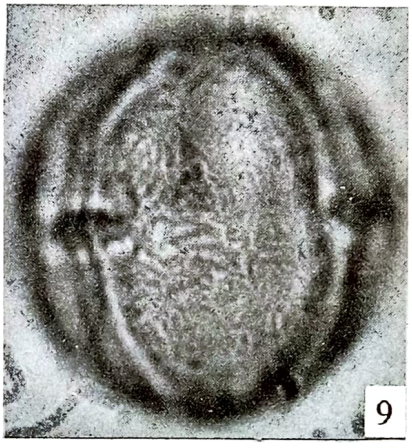


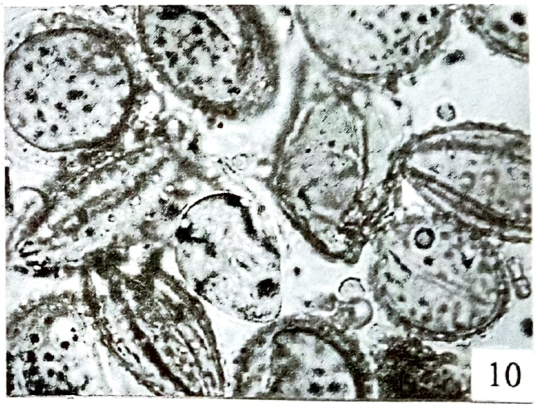


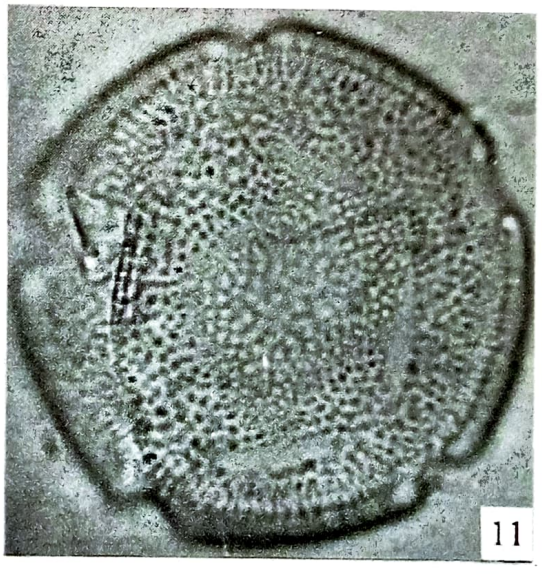


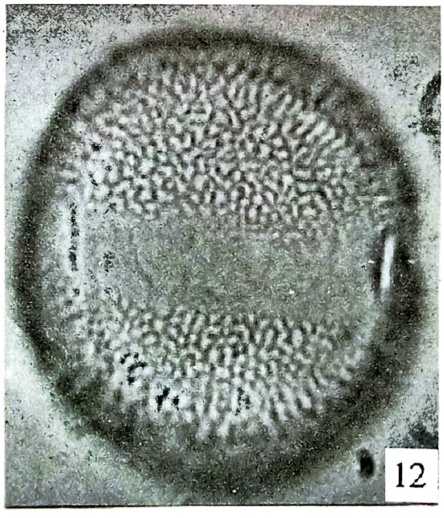












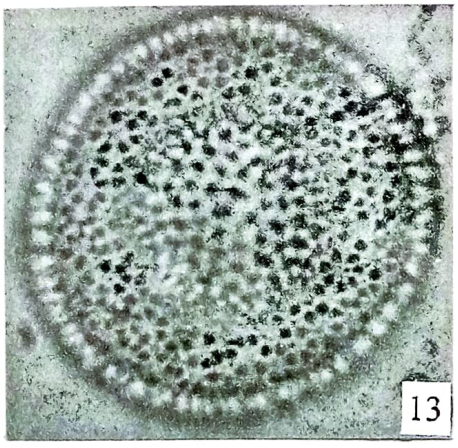
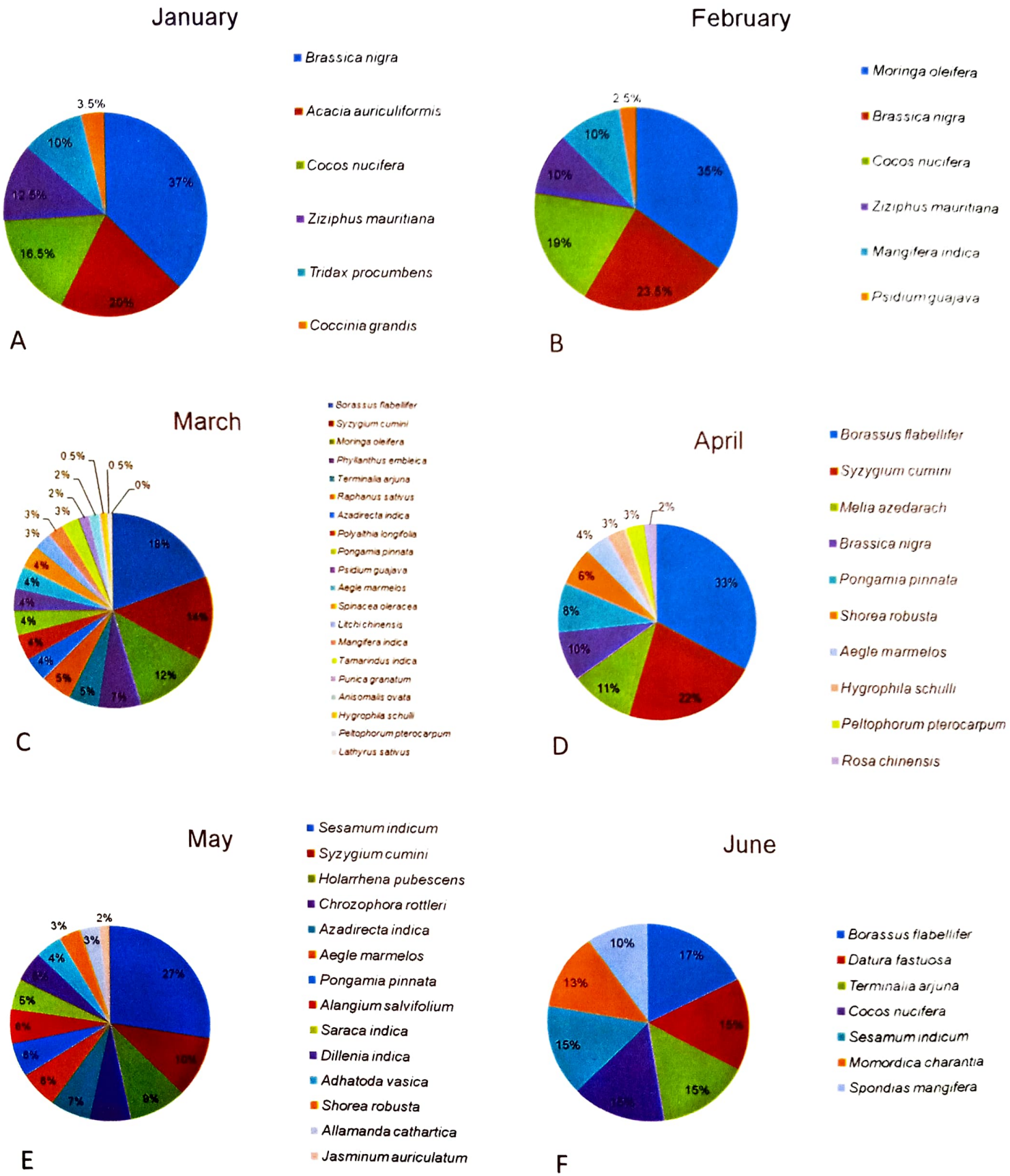
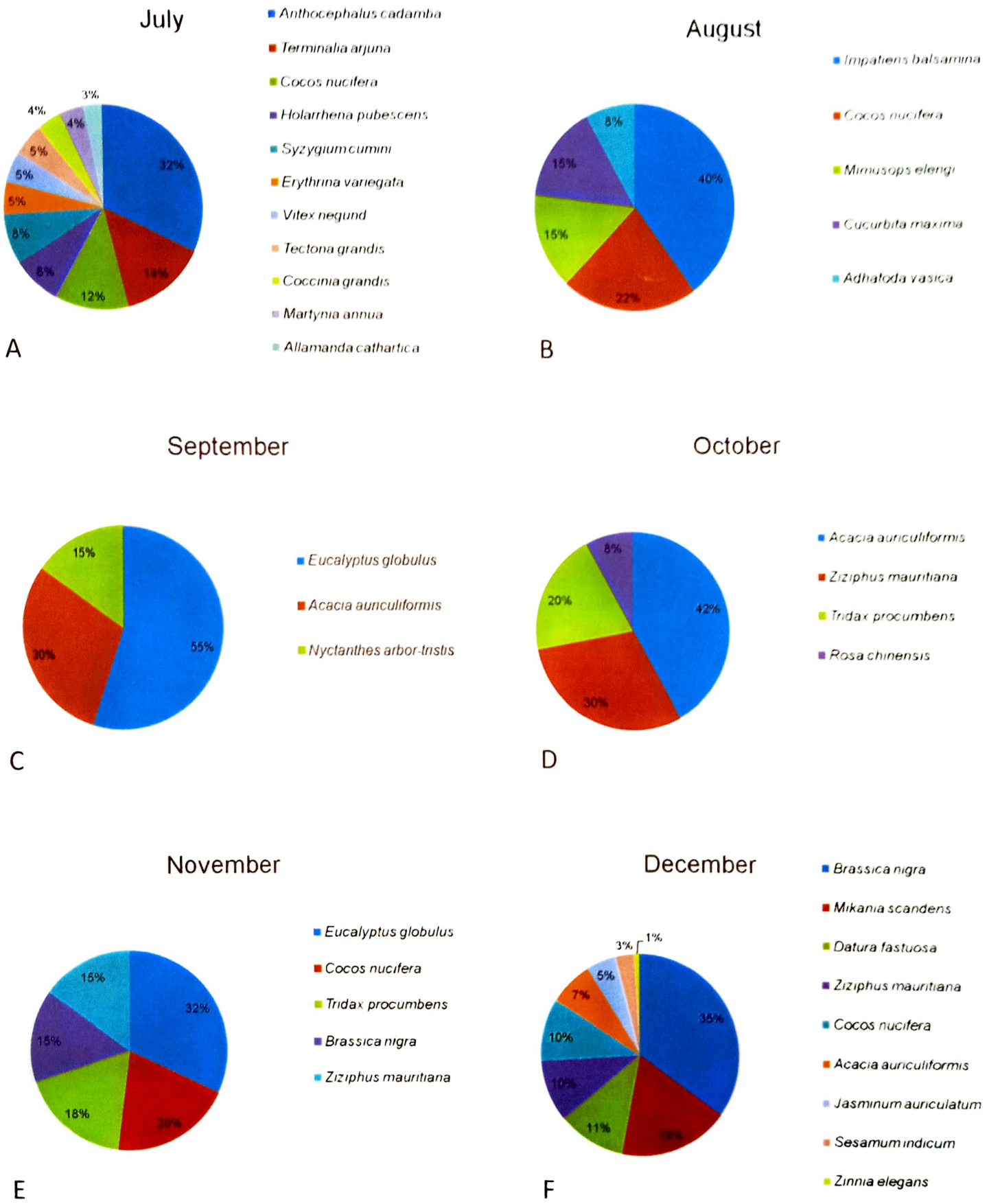


Plate 4



Text figure 4. Pie diagrammes of month-wise nectar forage by *Apis mellifera* in Gangetic West Bengal (January- June).



Text figure 5. Pie diagrammes of month-wise nectar forage by *Apis mellifera* in Gangetic West Bengal (July - December).

Table 2. Nectar forage calendar of *Apis mellifera* in Gangetic West Bengal.

Incidence Month	Most frequent	Moderately frequent	Less frequent
JAN	*Brassica nigra, Acacia auriculiformis*	*Cocos nucifera, Ziziphus mauritiana, Tridax procumbens*	*Coccinia grandis*
FEB	*Moringa oleifera, Brassica nigra*	*Cocos nucifera, Ziziphus mauritiana, Mangifera indica*	*Psidium guajava*
MAR	–	*Borassus flabellifer, Syzygium cumini, Moringa oleifera, Phyllanthus emblica, Terminalia arjuna, Raphanus sativus,*	*Aegle marmelos, Azadirachta indica, Polyalthia longifolia, Pongamia pinnata, Psidium guajava, Spinacea oleracea, Litchi chinensis, Mangifera indica, Tamarindus indica, Punica granatum, Anisomeles ovata, Hygrophylla schulli, Lathyrus sativus, Peltophorum pterocarpum*
APR	*Borassus flabellifer, Syzygium cumini*	*Melia azedarach, Brassica nigra, Pongamia pinnata, Shorea robusta*	*Aegle marmelos, Hygrophylla schulli, Peltophorum pterocarpum, Rosa chinensis*
MAY	*Sesamum indicum*	*Syzygium cumini, Holarrhena pubescens, Chrozophora rottleri, Azadirachta indica, Aegle marmelos, Pongamia pinnata, Alangium salvifolium, Saraca indica, Dillenia indica*	*Adhatoda vasica, Allamanda cathartica,Shorea robusta, Jasminum auriculatum*
JUN	–	*Borassus flabellifer, Cocos nucifera, Datura fastuosa, Sesamum indicum, Terminalia arjuna, Momordica charantia, Spondias mangifera*	–
JUL	*Anthocephalus cadamba*	*Terminalia arjuna, Cocos nucifera, , Holarrhena pubescens, Syzygium cumini, Erythrina variegata,Vitex negundo, Tectona grandis*	*Coccinia grandis, Martynia annua, Allamanda cathartica*
AUG	*Impatiens balsamina, Cocos nucifera*	*Cucurbita maxima, Mimusops elengi, Adhatoda vasica*	–
SEP	*Eucalyptus globulus, Acacia auriculiformis*	*Nyctanthes arbortristis*	–
OCT	*Acacia auriculiformis, Ziziphus mauritiana, Tridax procumbens*	*Rosa chinensis*	–
NOV	*Eucalyptus globulus, Cocos nucifera*	*Tridax procumbens, Brassica nigra, Ziziphus mauritiana*	–
DEC	*Brassica nigra*	*Mikania scandens, Datura fastuosa, Cocos nucifera, Ziziphus mauritiana, Acacia auriculiformis, Jasminum auriculatum*	*Sesamum indicum, Zinnia elegans*

Tamarindus indica, *Tectona grandis*, *Vitex negundo*, *Ziziphus mauritiana* and *Zinnia elegans*.

Out of the 73 species, 20 species serve exclusively as pollen source. Those are *Averrhoa carambola*, *Barringtonia acutangula*, *Bauhinia malabarica*, *Carica papaya*, *Citrus maxima*, *Cleome viscosa*, *Cordia sebestena*, *Croton bonplandianum*, *Gmelina arborea*, *Jatropha gossypifolia*, *Lagerstroemia speciosa*, *Luffa acutangula*, *Monochoria hastata*, *Murraya paniculata*, *Phoenix sylvestris*, *Poa gangetica*, *Sida acuta*, *Solanum melongena*, *Syzygium jambos* and *Xanthium strumarium*.

Remaining 20 species provide both nectar and pollen. Those are *Acacia auriculiformis*, *Aegle marmelos*, *Anthocephalus cadamba*, *Borassus flabellifer*, *Brassica nigra*, *Chrozophora rottleri*, *Cocos nucifera*, *Dillenia indica*, *Eucalyptus globulus*, *Litchi chinensis*, *Martynia annua*, *Phyllanthus emblica*, *Polyalthia longifolia*, *Pongamia pinnata*, *Spondius mangifera*, *Saraca indica*, *Terminalia arjuna*, *Shorea robusta* and *Tridax procumbens*.

The month-wise forage calendar, with respect to both pollen grains and nectar, of *Apis mellifera* in

Table 3. Month wise forage calendar of *Apis mellifera* in Gangetic West Bengal.

Forage Month	POLLEN FORAGE	NECTAR FORAGE
JAN	Most frequent: *Cocos nucifera, Tridax procumbens* Moderately frequent: *Phoenix sylvestris, Luffa acutangula, Brassica nigra* Less frequent: -	Most frequent: *Brassica nigra, Acacia auriculiformis* Moderately frequent: *Cocos nucifera, Ziziphus mauritiana, Tridax procumbens* Less frequent: *Coccinia grandis*
FEB	Most frequent: *Cocos nucifera, Phoenix sylvestris* Moderately frequent: *Aegle marmelos, Tridax procumbens,Solanum melongena, Litchi chinensis* Less frequent: *Bauhinia malabárica*	Most frequent: *Moringa oleifera, Brassica nigra* Moderately frequent: *Cocos nucifera, Ziziphus mauritiana, Mangifera indica* Less frequent: *Psidium guajava*
MAR	Most frequent: - Moderately frequent: *Borassus flabellifer, Citrus maxima, Aegle marmelos, Carica papaya, Gmelina arborea, Syzygium cumini, Phyllanthus emblica, Spondias mangifera, Terminalia arjuna* Less frequent: *Polyalthia longifolia, Cocos nucifera, Litchi chinensis, Saraca indica*	Most frequent: - Moderately frequent: *Borassus flabellifer, Syzygium cumini, Moringa oleifera, Phyllanthus emblica, Terminalia arjuna, Raphanus sativus* Less frequent: *Aegle marmelos, Azadirachta indica, Polyalthia longifolia, Pongamia pinnata, Psidium guajava, Spinacea oleracea, Litchi chinensis, Mangifera indica, Tamarindus indica, Punica granatum, Anisomeles ovata, Hygrophylla schulli, Lathyrus stivus, Peltophorum pterocarpum*
APR	Most frequent: - Moderately frequent: *Terminalia arjuna, Luffa acutangula, Pongamia pinnata, Borassus flabellifer Polyalthia longifolia, Spondias mangifera, Cocos nucifera, Shorea robusta* Less frequent: *Polyalthia longifolia, Cocos nucifera, Litchi chinensis, Saraca indica*	Most frequent: *Borassus flabellifer, Syzygium cumini* Moderately frequent: *Melia azedarach, Brassica nigra, Pongamia pinnata, Shorea robusta* Less frequent: *Aegle marmelos, Hygrophylla schulli, Peltophorum pterocarpum, Rosa chinensis*
MAY	Most frequent: *Borassus flabellifer, Cocos nucifera* Moderately frequent: *Lagerstroemia speciosa, Luffa acutangula, Citrus máxima* Less frequent: *Chrozophora rottleri, Cordia sebestina, Barringtonia acutangula, Syzygium jambos*	Most frequent: *Sesamum indicum* Moderately frequent: *Syzygium cumini, Holarrhena pubescens, Chrozophora rottleri, Azadirachta indica, Aegle marmelos, Pongamia pinnata, Alangium salvifolium, Saraca indica, Dillenia indica* Less frequent: *Adhatoda vasica, Allamanda cathartica,Shorea robusta, Jasminum auriculatum*
JUN	Most frequent: *Averrhoa carambola, Cocos nucifera* Moderately frequent: *Bauhinia malabarica, Chrozophora rottleri, Borassus flabellifer, Lagerstroemia speciosa, Jatropha gossypifolia, Dillenia indica* Less frequent: *Croton bonplandianum, Syzygium cumini, Cordia sebestina, Cleome viscosa*	Most frequent: - Moderately frequent: *Borassus flabellifer, Cocos nucifera, Datura fastuosa, Sesamum indicum, Terminalia arjuna, Momordica charantia, Spondias mangifera* Less frequent: -
JUL	Most frequent: - Moderately frequent: *Anthocephalus cadamba, Cleome viscosa, Monochoria hastata, Cocos nucifera, Acacia auriculiformis, Murraya paniculata, Averrhoa carambola, Lagerstroemia speciosa* Less frequent: *Eucalyptus globulus, Syzygium cumini, Bauhinia malabárica*	Most frequent: *Anthocephalus cadamba* Moderately frequent: *Terminalia arjuna, Cocos nucifera, , Holarrhena pubescens, Syzygium cumini, Erythrina variegata,Vitex negundo, Tectona grandis* Less frequent: *Coccinia grandis, Martynia annua, Allamanda cathartica*
AUG	Most frequent: *Cocos nucifera* Moderately frequent: *Murraya paniculata, Anthocephalus cadamba, Borassus flabellifer, Bauhinia malabarica,Cleome viscosa* Less frequent: *Acacia auriculiformis, Monochoria hastata*	Most frequent: *Impatiens balsamina, Cocos nucifera* Moderately frequent: *Cucurbita maxima, Mimusops elengi, Adhatoda vasica* Less frequent: -

SEP	Most frequent: *Acacia auriculiformis, Cocos nucifera* Moderately frequent: *Eucalyptus globulus, Martynia annua, Sida acuta, Poa gangetica* Less frequent: *Bauhinia malabarica, Monochoria hastata, Murraya paniculata*	Most frequent: *Eucalyptus globulus, Acacia auriculiformis* Moderately frequent: *Nyctanthes arbortristis* Less frequent: -
OCT	Most frequent: *Acacia auriculiformis, Xanthium strumarium* Moderately frequent: *Cocos nucifera, Murraya paniculata, Monochoria hastata, Sida acuta, Tridax procumbens* Less frequent: -	Most frequent: *Acacia auriculiformis, Ziziphus mauritiana, Tridax procumbens* Moderately frequent: *Rosa chinensis* Less frequent: -
NOV	Most frequent: *Cocos nucifera* Moderately frequent: *Acacia auriculiformis, Tridax procumbens, Brassica nigra, Monochoria hastata, Luffa acutangula, Sida acuta, Xanthium strumarium* Less frequent: *Eucalyptus globulus*	Most frequent: *Eucalyptus globulus, Cocos nucifera* Moderately frequent: *Tridax procumbens, Brassica nigra, Ziziphus mauritiana* Less frequent: -
DEC	Most frequent: *Acacia auriculiformis, Brassica nigra, Cocos nucifera* Moderately frequent: *Sida acuta, Luffa acutangula, Tridax procumbens* Less frequent: -	Most frequent: *Brassica nigra* Moderately frequent: *Mikania scandens, Datura fastuosa, Cocos nucifera, Ziziphus mauritiana, Acacia auriculiformis, Jasminum auriculatum* Less frequent: *Sesamum indicum, Zinnia elegans*

Gangetic West Bengal is detailed in Table 3.

As mentioned earlier, from the production point of view, apiculture is a seasonal practice in Gangetic West Bengal. During the period from the late January to early May and from mid September to early November, *Apis mellifera* accumulates surplus honey enabling commercial extraction. Therefore, late January to early May and mid September to early November, are the productive seasons when honey is extracted by the beekeepers from the hives for commercial purpose. On the other hand, the periods from mid May to early September and mid November to mid January can be regarded as the stress seasons because of the poor foraging by bees due to unfavourable weather condition together with floral dearth. For sustenance of the bee colonies, beekeepers are often compelled to supply very dilute sugar solution in their hives. However, sucrose is not at all an adequate substitute of nectar and pollen for balanced nutrition and maintenance of proper vigour of a bee colony. During those stress seasons, the following plants constitute the bee pasturage: *Acacia auriculiformis, Adhatoda vasica, Allamanda cathartica, Anthocephalus cadamba, Averrhoa carambola, Bauhinia malabarica, Borassus flabellifer, Cleome viscosa, Coccinia grandis, Cocos nucifera, Cucurbita maxima, Datura fastuosa, Erythrina variegata, Eucalyptus globulus, Holarrhena pubescens, Impatiens balsamina, Lagerstroemia speciosa, Martynia annua, Mimusops elengi, Momordica charantia, Monochoria hastata, Murraya paniculata, Nyctanthes arbor-tristis, Sesamum indicum, Spondias mangifera, Syzygium cumini, Tectona grandis, Terminalia arjuna* and *Vitex negundo*. These are of immense importance for sustenance of bee colonies during the stress periods.

The pollen spectra of honey samples reveal that *Apis mellifera* in gangetic West Bengal produce primarily multifloral honeys during the major part of the year. However, in September it produces unifloral honeys of *Eucalyptus globulus* type.

The overall forage calendar of *A. mellifera*, as has presently been worked out, includes the following agricultural or horticultural plants cultivated in the region: *Aegle marmelos, Averrhoa carambola, Brassica nigra, Carica papaya, Citrus maxima, Coccinia grandis, Cocos nucifera, Cucurbita maxima, Dillenia indica, Litchi chinensis, Luffa acutangula, Mangifera indica, Momordica charantia, Moringa oleifera, Phyllanthus emblica, Psidium guajava, Punica granatum, Sesamum indicum, Solanum melongena, Spondias mangifera, Syzygium cumini, Syzygium jambos, Tamarindus indica* and *Ziziphus mauritiana*. As bees are known to be one of the most

effective groups of pollinators, therefore, while visiting the flowers of above mentioned crops to collect pollen or nectar or both, they may help in their pollination. Therefore, in view of the recent pollination crisis, possibility of use of *A. mellifera* hives can be explored for enhancing the yield of those crops.

ACKNOWLEDGEMENT

The authors are thankful to the authorities of the University of Burdwan for providing necessary laboratory and library fecilities. Thanks are also due to Mr. Ashok Sashmal of Singur, Mr. Dinanath Kamle of Noapara, Mr. Sabbir Ali of Berhampur and Mr. Pran Kumar Banerjee of Burdwan for their help in collection of samples of pollen pellets and honey from time to time. A Research Fellowship awarded to one of the authors (P. K.) by the Government of West Bengal is also gratefully acknowledged

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